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Biochar soil application to mitigate climate change

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Biochar soil application to mitigate global change

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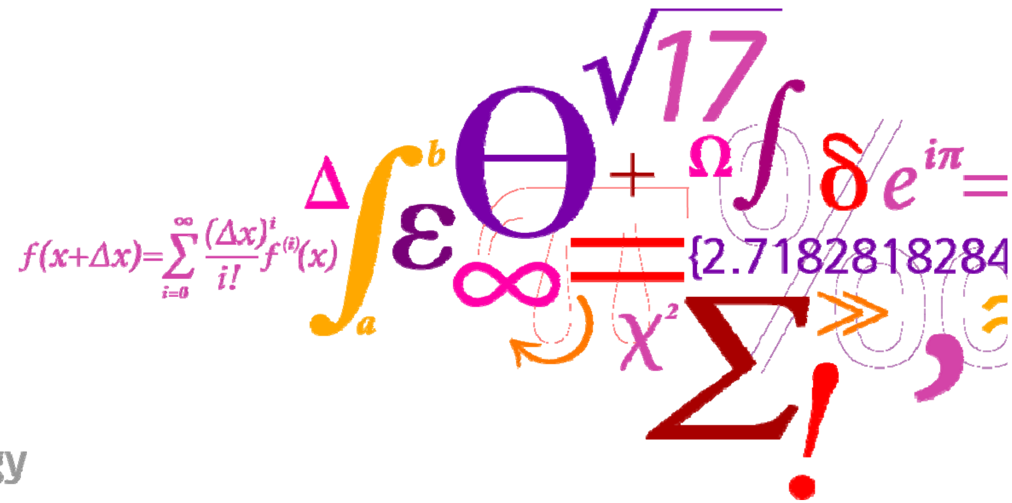


Risø DTU
National Laboratory for Sustainable Energy

Introduction to biochar

What is biochar?

- Biochar is just another word for charcoal

How is biochar made?

- Biochar is produced through the heating of biomass under air-deprived conditions. A process called pyrolysis.
- In the pyrolysis process bio-oil and gas are produced as well

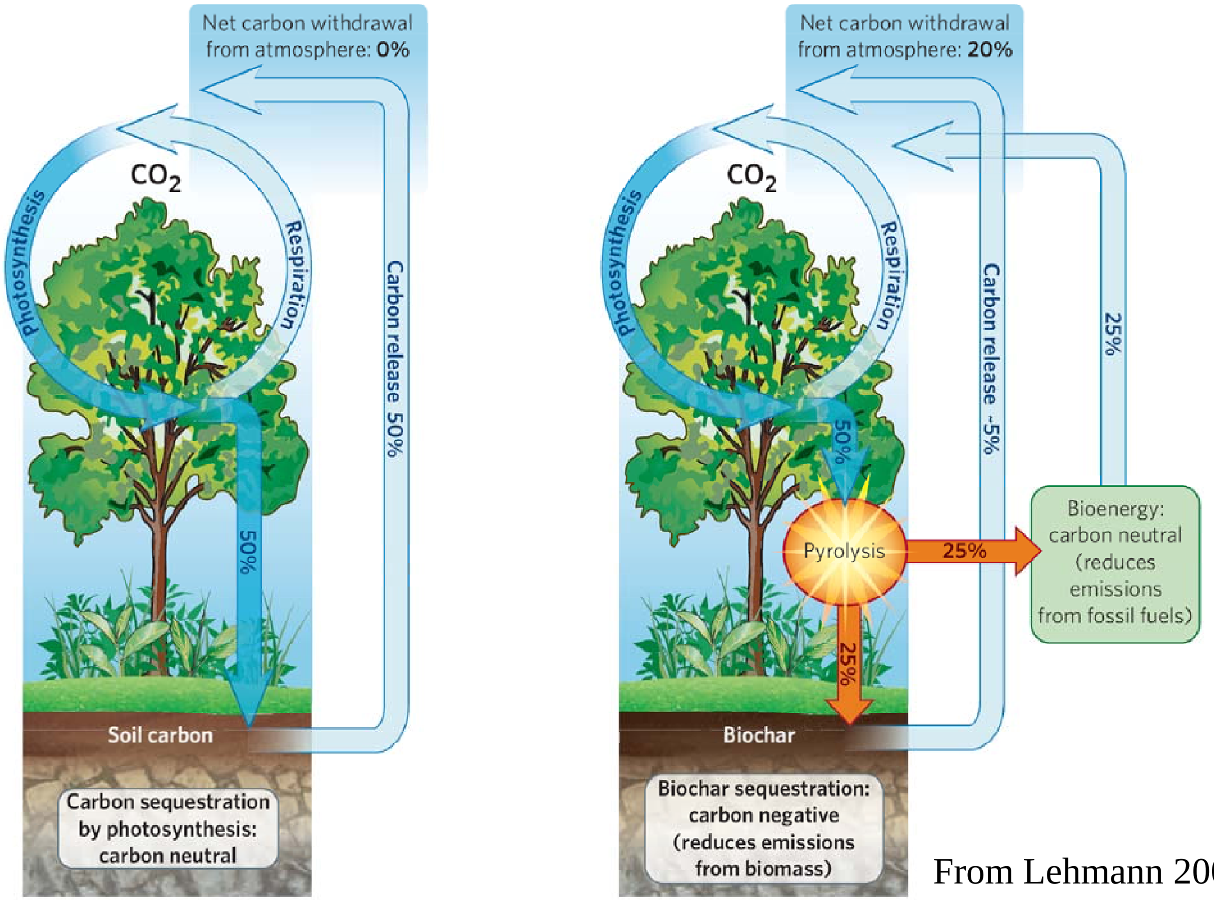
What are the benefits of biochar?

- Biochar can be used for carbon (C) sequestration (storage) and GHG inhibition in soil. Bio-oil can subsidize fossil fuels
- Biochar enhances soil fertility and crop yields

Soils are very important sinks for carbon!

- The application of biochar to agricultural lands is one way to increase soil C

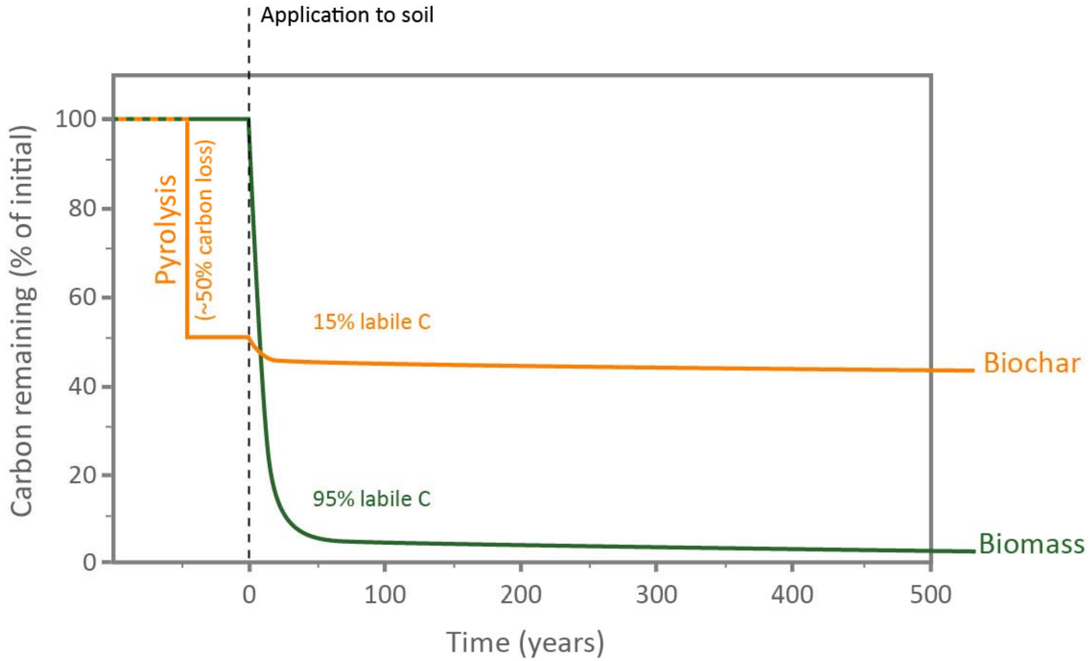
The mechanism behind C sequestration



From Lehmann 2007, Nature.

The stability of biochar in soil

- The stability of biochar is of fundamental importance as it determines how long biochar-C applied to soil will remain sequestered
- Biochar typically has the greatest average age of any C fraction
- Biochar from wildfires is frequently found to be more than 10,000 years old



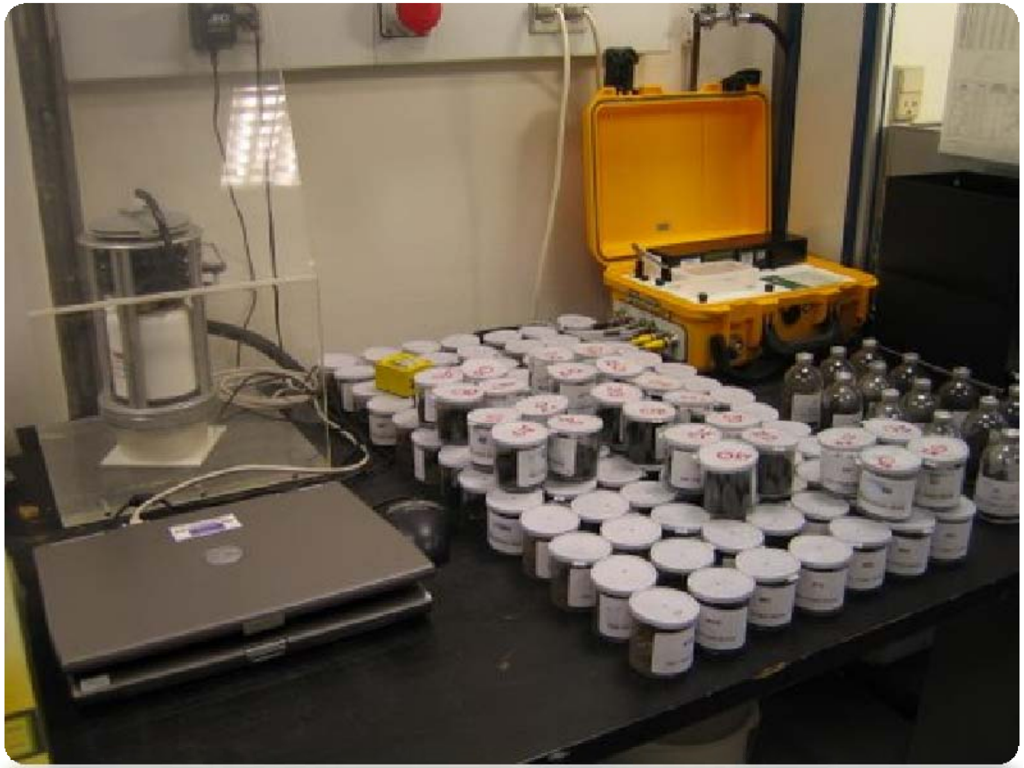
Is biochar to be taken seriously?

- Growing scientific and public awareness: Nature[2], Science[3] as well as BBC, Times and CNN have all published papers/information about biochar
- Dr. Johannes Lehmann has given testimony about biochar before the House of representatives (US) Select Committee on Energy Independence and Global Warming
- Companies already with pyrolysis production facilities are rising in numbers (e.g. Best Energies, Eprida, Dynamotive)

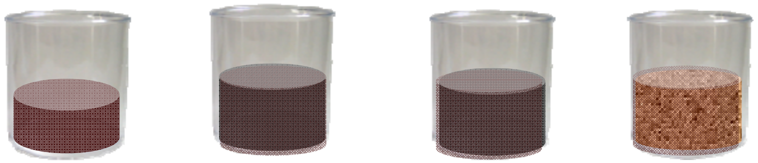
1) http://news.bbc.co.uk/2/hi/science/nature/7924373.stm ; 2) Lehmann J. (2007) 3) Wardle et al (2008). 4) Gaunt and Lehmann 2008

My research

- Incubation studies with focus on short term degradation of different types of biochars in a temperate loam soil

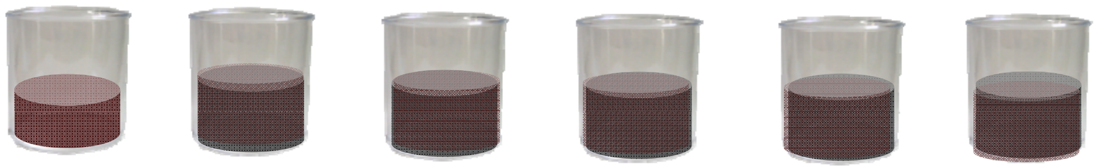


Mineralization of fast and slow pyrolysis biochar compared to straw



40g soil REF	+2g fast pyrolysis biochar	+2g slow pyrolysis biochar	+2g straw (feedstock for biochar)

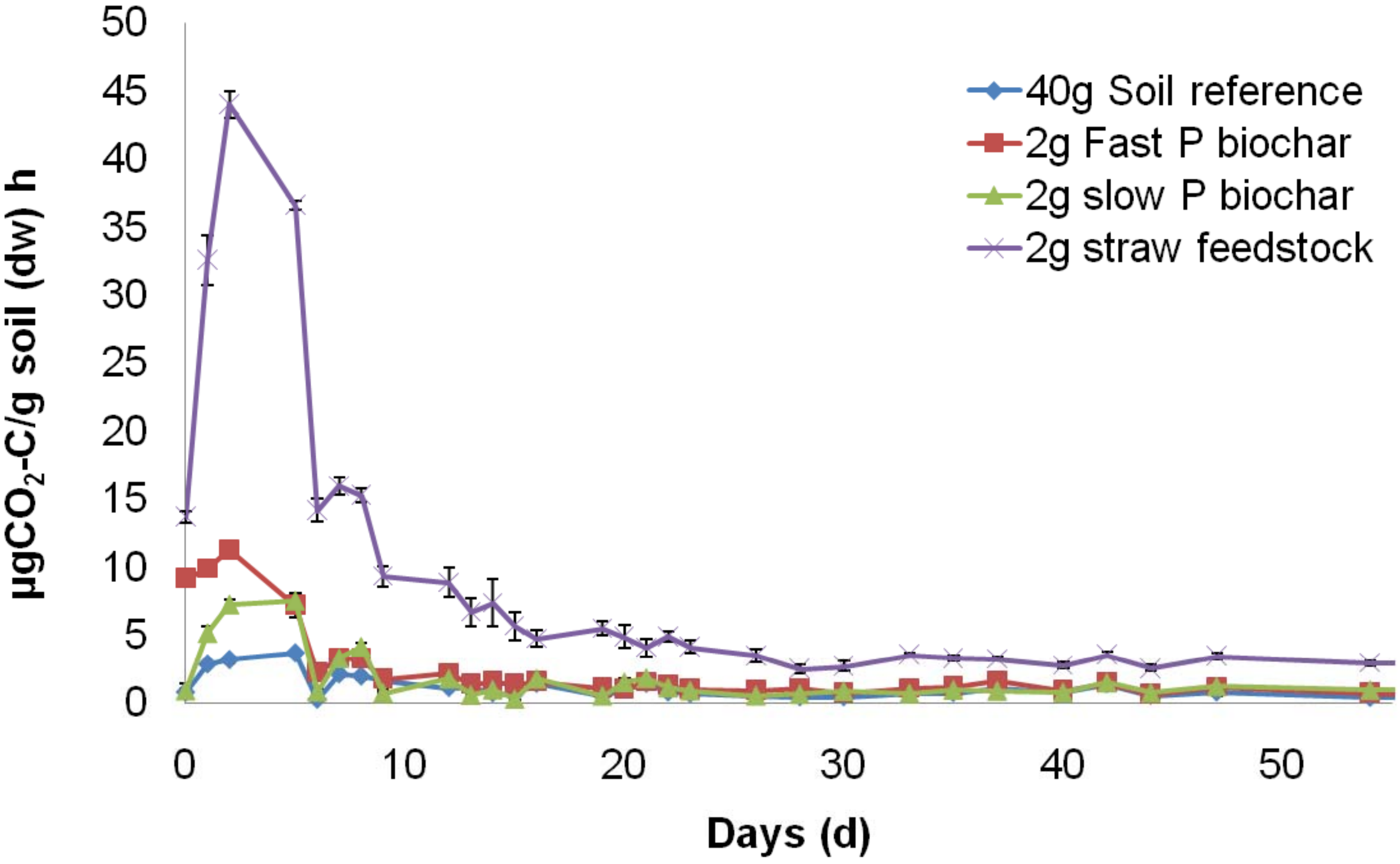
Mineralization of biochars made at different pyrolysis temperatures



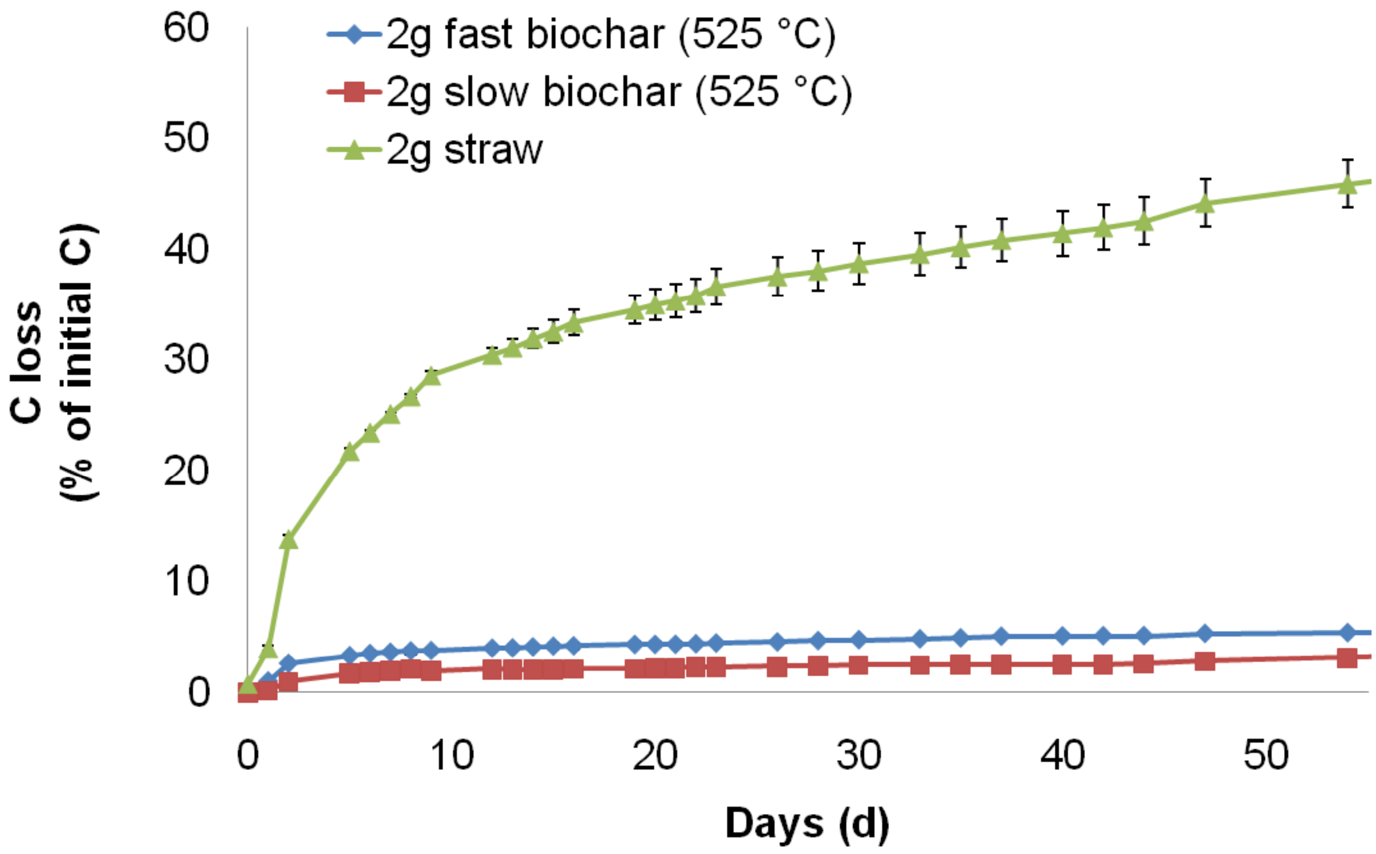
40g soil REF	+2g fast pyrolysis biochar 475°C	500°C	525°C	550°C	575°C

feedstock straw

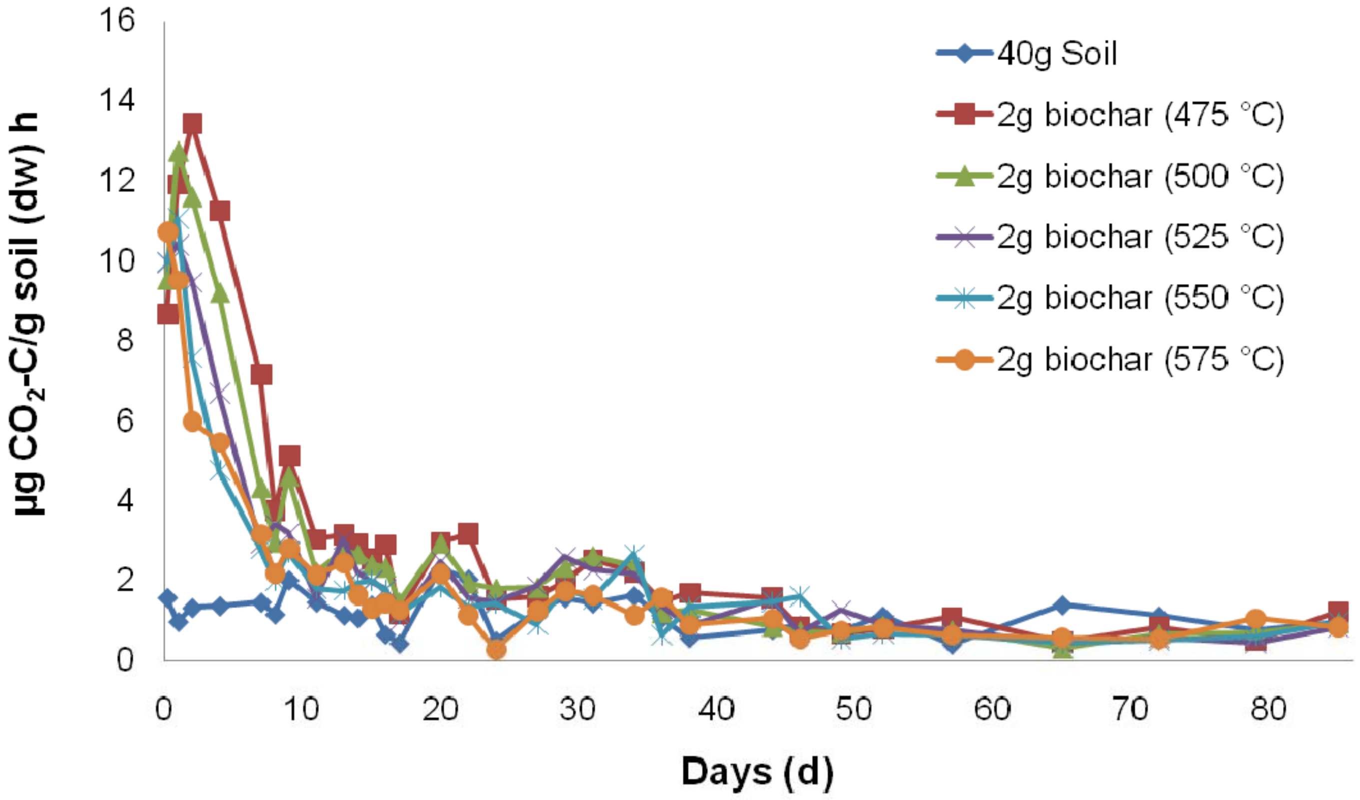
Mineralization of fast and slow pyrolysis biochar compared to straw



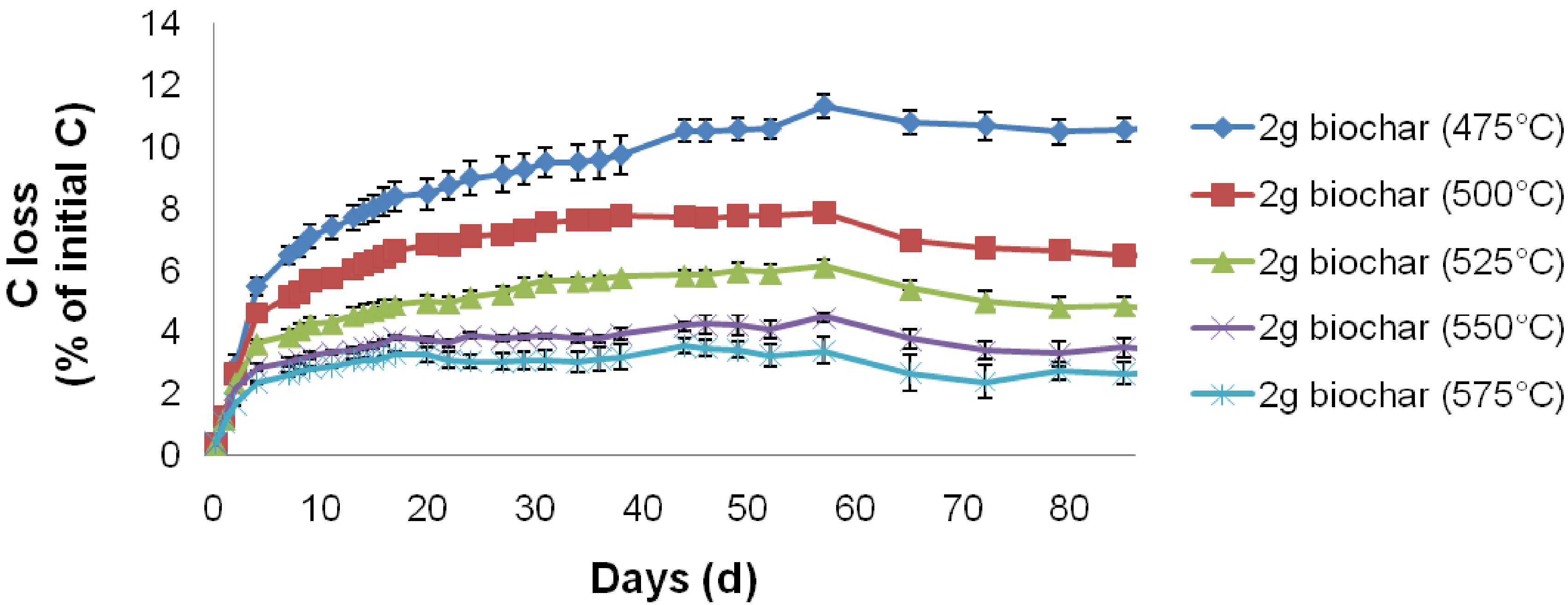
Cumulated C-loss



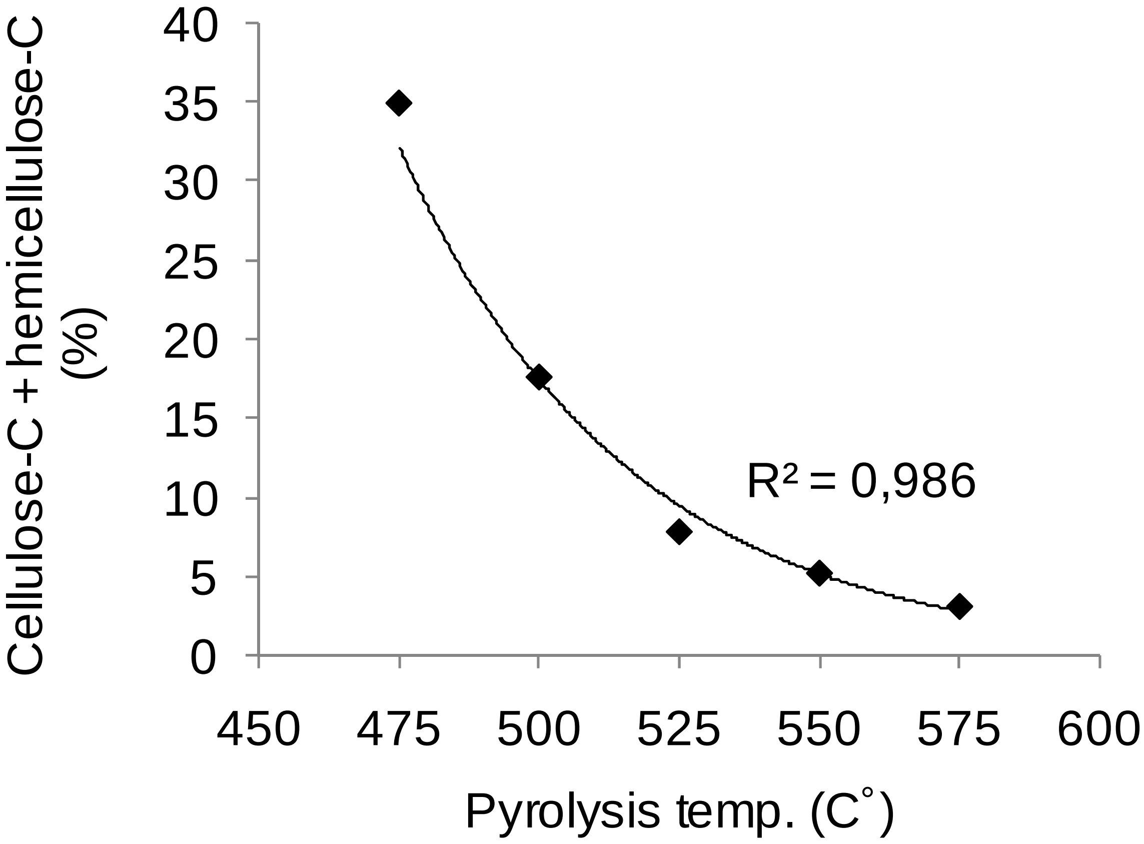
Mineralization of biochars made at different pyrolysis temperatures



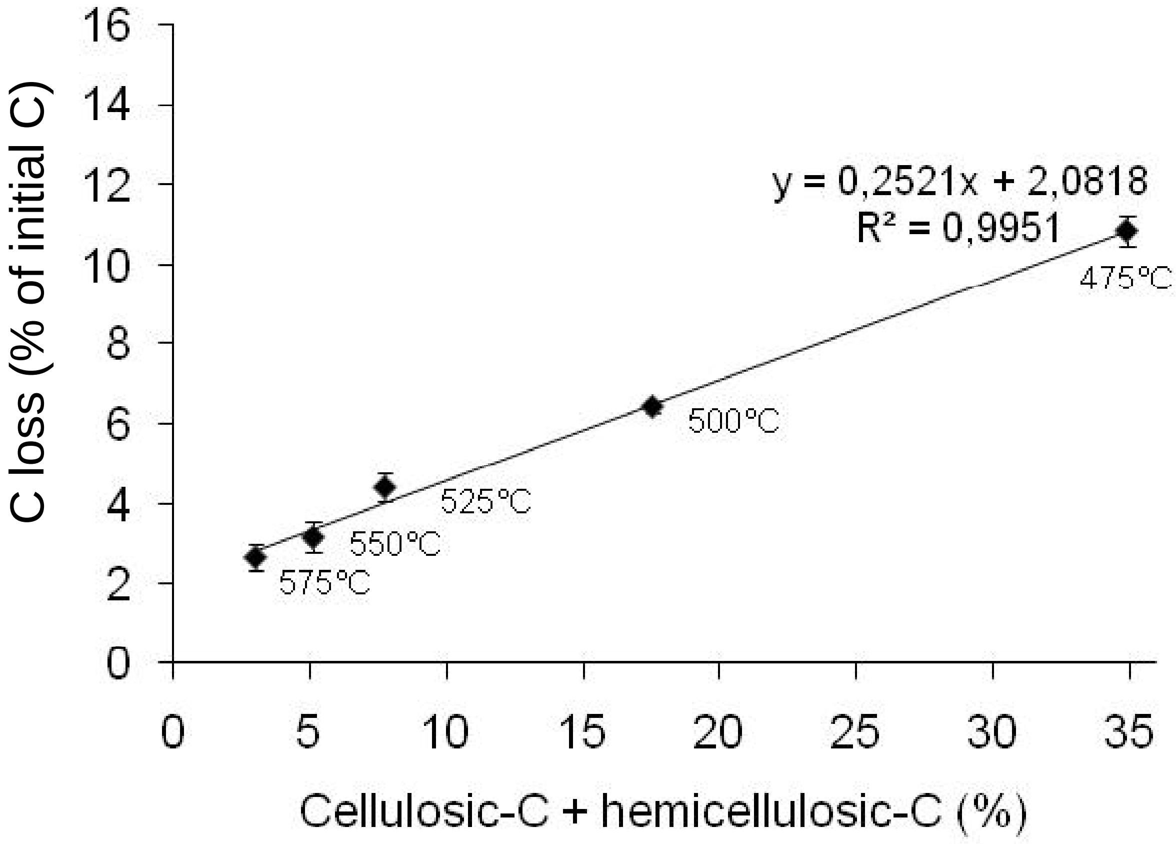
Cumulated biochar C loss (%)



Biochar cellulosic and hemicellulosic C fractions



Cellulosic and hemicellulosic fraction correlated with biochar-C decay



Conclusions

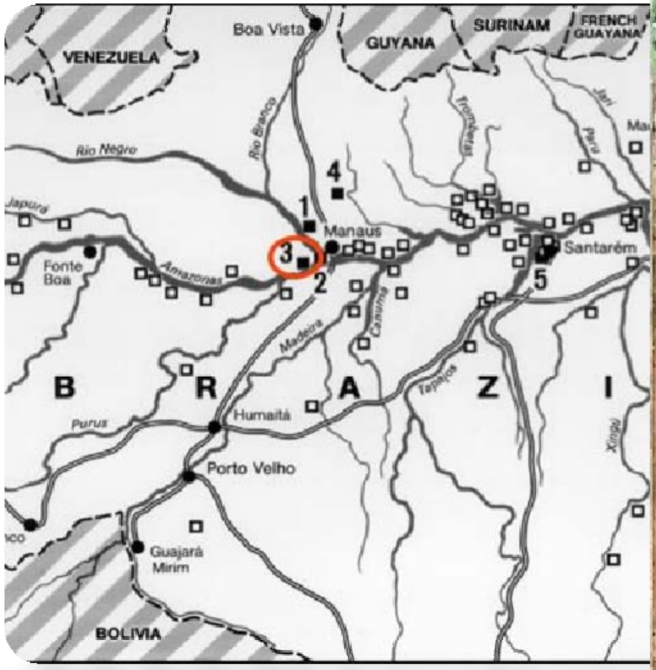
- biochar soil application can be used to store carbon in soil
- biochar carbon loss is correlated with the specific pyrolysis technology and production temperature
- short-term degradation of fast pyrolysis biochar is proportional to the content of cellulosic and hemicellulosic carbon in the biochar

- A holistic approach is recommended when managing the pyrolysis process, so both the produced bio-oil (and hence avoided use of fossil fuel) and biochar C-sequestration is optimized to give the overall largest net avoidance of CO_2 emissions

Thank you for your attention

- More information about biochar on: www.biochar-international.org/
- Special thank to Henrik Hauggaard-Nielsen, Per Ambus, Helge Egsgaard and Hanne Wojtaszewski and Tobias Thomsen

Appendix
Biochar has been used before:
Dark soils of Amazonas



Appendix
Biochar has been used before:
Dark soils of Amazonas

Biochar increases crop yields

Table 1 Relation between charcoal amendments to soil and crop response

Treatment	Amendment (Mg ha−1)	Biomass production (%)	Plant height (%)	Root biomass (%)	Shoot biomass (%)	Plant type	Soil type	Reference
Control	–	100	100	–	–	Bauhinia wood	Alfisol/Ultisol	Chidumayo (1994)
Charcoal	Unknown	113	124	–	–	Bauhinia wood	Alfisol/Ultisol	
Control	–	100	–	–	–	Soybean	Volcanic ash soil, loam	Kishimoto and Sugiura (1985)
Charcoal	0.5	151	–	–	–	Soybean	Volcanic ash soil, loam	Iswaran et al. (1980)
Charcoal	5.0	63	–	–	–	Soybean	Volcanic ash soil, loam	Kishimoto and Sugiura (1985)
Charcoal	15.0	29	–	–	–	Soybean	Volcanic ash soil, loam	
Control	–	100	–	–	–	Pea	Dehli soil	Iswaran et al. (1980)
Charcoal	0.5	160	–	–	–	Pea	Dehli soil	
Control	–	100	–	–	–	Moong	Dehli soil	
Charcoal	0.5	122	–	–	–	Moong	Dehli soil	
Control	–	100	–	100	–	Cowpea	Xanthic Ferralsol	Glaser et al. (2002a, 2002b)
Charcoal	33.6	127	–	–	–	Oats	Sand	
Charcoal	67.2	120	–	–	–	Rice	Xanthic Ferralsol	
Charcoal	67.2	150	–	140	–	Cowpea	Xanthic Ferralsol	
Charcoal	135.2	200	–	190	–	Cowpea	Xanthic Ferralsol	
Control	–	100	100	100	100	Maize	Alfisol	Mbagwu and Piccolo (1997)
Coal humic acid	0.2	118	114	122	114	Maize	Alfisol	
Coal humic acid	2.0	176	145	186	166	Maize	Alfisol	
Coal humic acid	20.0	132	125	144	120	Maize	Alfisol	
Control	–	100	100	100	100	Maize	Inceptisol	
Coal humic acid	0.2	125	119	122	127	Maize	Inceptisol	
Coal humic acid	2.0	186	148	198	173	Maize	Inceptisol	
Coal humic acid	20.0	139	131	147	130	Maize	Inceptisol	
Control	–	100	100	100	–	Sugi trees	Clay loam	Kishimoto and Sugiura (1985)
Wood charcoal	0.5	249	126	130	–	Sugi trees	Clay loam	
Bark charcoal	0.5	324	132	115	–	Sugi trees	Clay loam	
Activated charcoal	0.5	244	135	136	–	Sugi trees	Clay loam	


Kanso Technos, Japan
A
B
C
Plain Soil
NPK
Biochar + NPK


no Biochar


with Biochar

Physical properties

- Particle sizes in the range of 1µm to 1mm
- The porosity is large! 1g biochar typically has a surface area of 300-400m^2

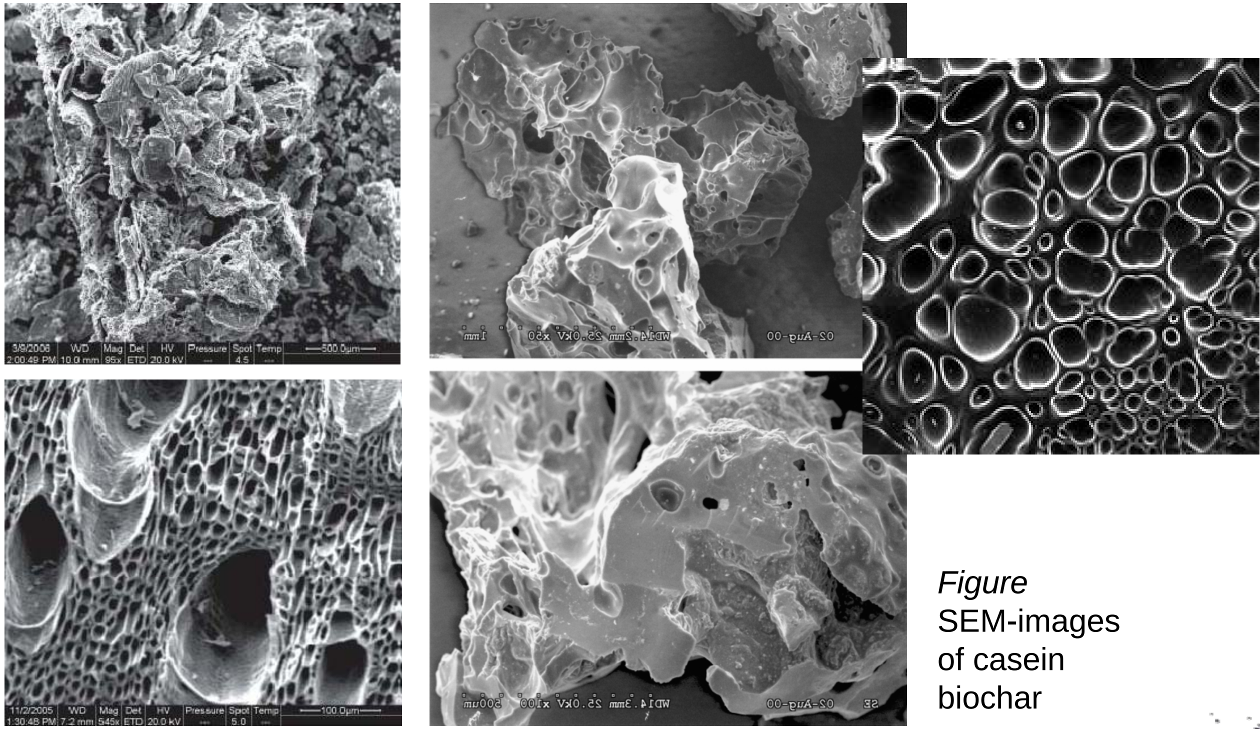
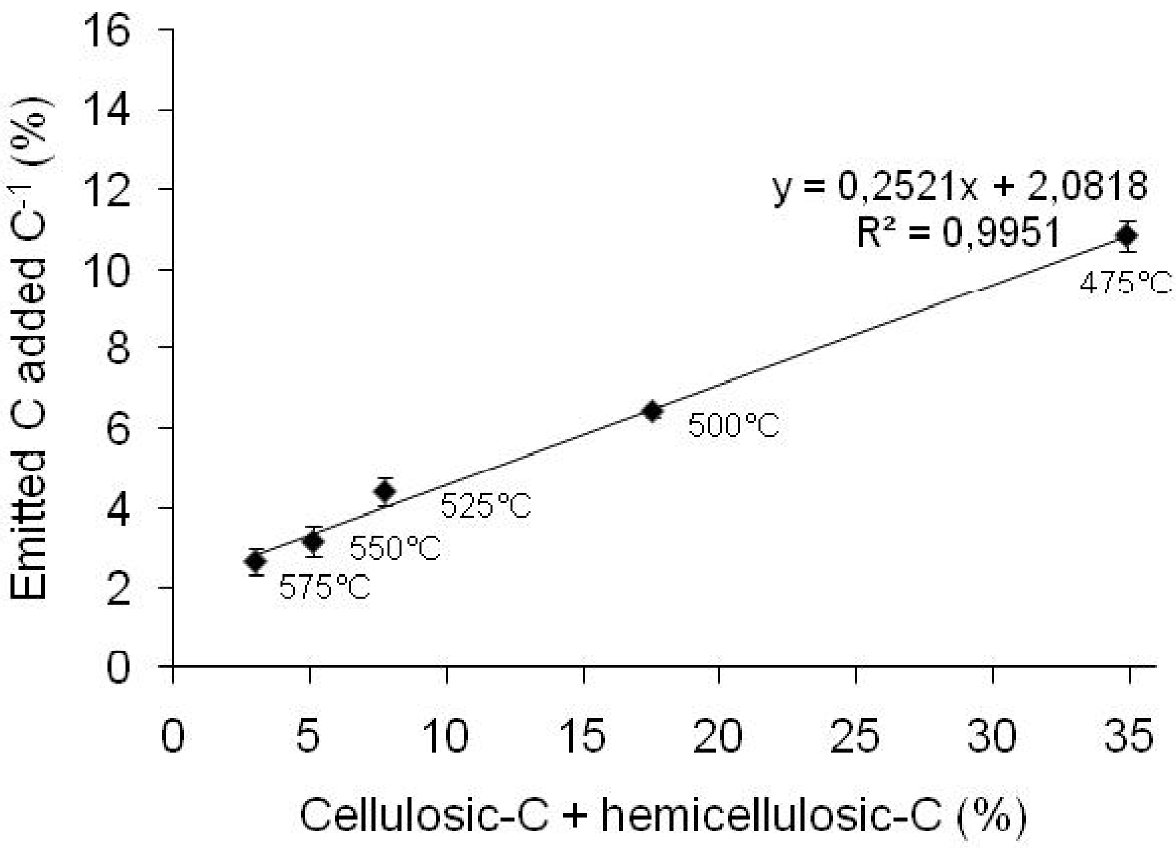


Figure
SEM-images of casein biochar

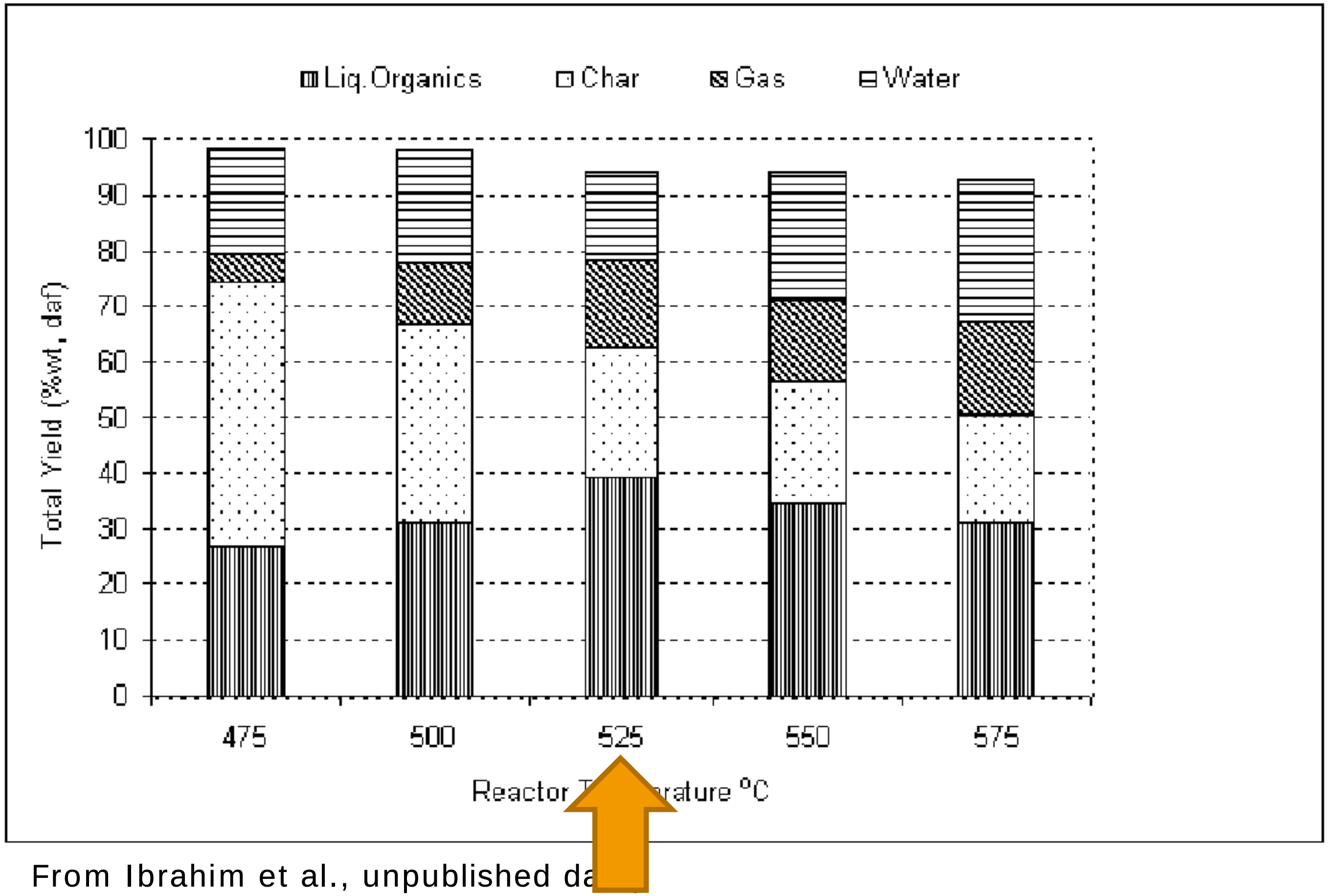
Table 1. Average particle sizes of the added biochars.

	Biochar 475°C	Biochar 500°C	Biochar 525°C	Biochar 550°C	Biochar 575°C
Average size (µm ±SE)	70.9±6	49.7±4.5	17.1±1.4	12±0.9	11.5±0.8
Min-max size	18.8-489.7	10.7-223.3	2.9-100.5	2.2-55.8	2.1-59.7



Optimal pyrolysis temperature

Overall mass balances for feedstock straw



From Ibrahim et al., unpublished data

Critical reflections

- Are there any health risk with biochar?
- how do we amend biochar with the soil?
- How do we avoid deforestation of primary forest (jungle) for biochar and biooil production?